MICRO-ORGANISM REDUCTION IN LIQUID BY USE OF A METAL HALIDE ULTRAVIOLET LAMP

Cross Reference To A Related Application

Applicant claims priority based on provisional application no. 60/217,498 filed July 11, 2000 and entitled "Micro-Organism Reduction In Liquid By Use Of A Metal Halide Ultraviolet Lamp", which is incorporated herein by reference.

Background Of The Invention

This invention related to the art of disinfection and pasteurization, and more particularly to a new and improved disinfection and pasteurization method and apparatus employing ultraviolet light.

Since the detection of the micro-organism has increase within the food industry, non-thermal disinfection and pasteurization methods to reduce micro-organism contamination have also increased. Metal halide ultraviolet lamps have been employed in surface sterilization as described in United States Patent No. 5,547,635 issued August 20, 1996 and entitled "Sterilization Method and Apparatus", the disclosure of which is hereby incorporated by reference.

Summary Of The Invention

The present invention provides a method and apparatus employing non-thermal pasteurization utilizing technology involving surface sterilization with metal halide ultraviolet lamps. This unique non-thermal

method of micro-organism reduction is achieved when a liquid is exposed to a high energy, metal halide, ultraviolet lamp in an enclosed sealed chamber capable of allowing liquid flow into and out of a vessel. The radiation from the lamp will penetrate the liquid reducing the organism. The method comprises rapid heat transfer, titanium dioxide penetration and ultraviolet impregnation of the micro-organism within the liquid.

The following detailed description of the invention when read in conjunction with the accompanying drawings, is in such full, clear, concise and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same.

Brief Description Of the Drawing

Fig. 1 is a side elevational view of the apparatus according to the present invention;

Fig. 2 is a view similar to Fig. 1 rotated ninety degrees;

Fig. 3 is an end elevational view of the apparatus of Figs. 1 and 2;

Fig. 4 is a perspective view with parts removed of the apparatus of the present invention;

Fig. 5 is a side elevational view of another form of the apparatus of the present invention;

Fig. 6 is a graph providing background for illustrating the method of the present invention;

Fig. 7 is a graph further illustrating the method of the present invention;

Fig. 8 is a diagrammatic view further illustrating the method of the present invention; and

Figs. 9-13 are charts and graphs further illustrating the invention.

Detailed Description Of the Invention

The method and apparatus of the present invention employs non-thermal pasteurization utilizing research and technology involving surface sterilization with metal halide ultraviolet lamps. This unique non-thermal method of micro-organism reduction is achieved when a liquid is exposed to a high energy, metal halide, ultraviolet lamp in an enclosed sealed chamber capable of allowing liquid flow into and out of a vessel. The radiation from the lamp will penetrate the liquid reducing the organism.

Referring to Figs. 1-3, the lamp, 10 with a metal halide configuration consisting of mercury and gallium, enclosed in a ozone free metallic doped quartz envelope, and having a wave length from about 175 to about 450 nanometers, is encapsulated in a second ozone free, metallic doped quartz tube 12. The metallic doping for the lamp envelope and tube 12 is titanium. Lamp 10 is similar to the lamp employed in the method and apparatus of the above-referenced patent 5,547,635. The quartz

tube is sealed in a vessel 14 comprised of an inlet 16, cylindrical chamber 18 enveloping the tube, and an outlet 20.

When the lamp 10 is ignited from an electronic ballast (not shown) in a circuit connected to the wires 22, 24 the lamp operates from about 175 nanometers to about 450 nanometers at a temperature ranging from about 600 degrees centigrade at the ends of the lamp to about 800 degrees centigrade at the center of the lamp. The afore-mentioned circuit can be similar to that shown in the above-referenced patent 5,547,635. The diameter of the vessel 14 is about twice the diameter of the tube 12 which in turn is twice the diameter of the lamp 10. The lamp 10 is approximately ½ inch diameter by about 16 inches in length for a ratio of about 100 watts per inch length at ½ inch diameter.

Liquid flow is dependent on the lamp output. Flow rate for penetrations about 0.1 gal/min./watt/vessel. This equates to a greater than five log reduction of micro-organism.

The process comprises rapid heat transfer and ultraviolet impregnation of the micro-organism within the liquid over the described period, and may also include titanium dioxide penetration. Ultraviolet light and heat from lamp 10 are introduced to the liquid flowing through vessel 14. Tuber 12 allows ultraviolet light to be transmitted therethrough without appreciable buildup of ozone. The term rapid heat transfer used herein has the same general meaning as employed in describing the dry heat type of sterilization method. With rapid heat transfer, sterilization is time efficient with items drying

quickly, in dry heat methods. In rapid heat transfer, as temperature increases, time decreases. It has been said that one way to get rapid heat transfer is to sterilize, not statically in a vessel but in a heat exchanger. The fluid is pumped continuously, and there is excellent energy economy by letting the hot sterilized medium exchange with the incoming medium. Applying the foregoing to the instant situation, the lamp 10, air and quartz tube 12 comprise the hot sterilized medium and the fluid or liquid flowing through vessel 14 comprises the exchange medium.

The unique non-thermal micro-organism reduction method additionally has implication in the medical industry.

Fig. 5 illustrates another form of the apparatus of the invention wherein two units 40 and 42 are located within a housing 44 and connected in series. Each unit 40, 42 is similar to the apparatus shown in Figs. 1-4 with an inlet on one and an outlet on the other.

The method and apparatus of the present invention employs synergistic inactivation and disinfection as a method of killing microorganisms by use of high intensity, broadband ultraviolet light combined with rapid heat transfer. This innovative and effective technology has particularly advantageous application to the food industry. However, the process has broad reaching potential applications far beyond the food industry, including the treatment of liquids, gasses and solids.

The method and apparatus offer the following advantages over conventional methods of pasteurization for biological decontamination: non thermal, portable, nontoxic, no harmful radiation, electric and uncomplicated.

The method and apparatus of the present invention are further illustrated by the electromagnetic spectrum shown in Figure 6. Specific wavelengths in the region within lines 50, 52 show extremely high efficiency for producing a germicidal effect. In Figure 7, the relationship between bacterial effects and wavelengths can be seen from the curve 60. The maximum bactericidal effectiveness is manifested at 2,537 A, where 90% of exposed microorganisms are inactivated.

The mechanism of germicidal action occurs as a result of the ultraviolet (UV) absorption by the nucleic acids or their components. This is the initial event in the chain of reactions leading to demise. Most of the damage elicited by UV light results in the formation of cyclobutane-type dimers between adjacent thymines in deoxyribonucleic acid as shown in Fig. 8. Similar dimers also form in lesser amounts between cytosines and between thymine-cytosine pairs. The dimers are extremely stable and they block the normal replication and transcription of the DNA. These irreversible changes comprise cellular function, which eventually leads to death. The amount of photon energy necessary to destroy microorganisms depends primarily on the sensitivity of the organism. Thus, ultraviolet light causes adjacent thymines (or cytosines) in DNA to dimerize. The rippled lines 70 and 72 in Fig. 8 at the

bottom of the structures represent the deoxyribose-phosphate backbone of the DNA strand.

Clarification of terms is required to understand the application of UV light. Sterilization is defined as the elimination or total destruction of microbial and viral life. Disinfection is the reduction of pathogenic microorganisms to a safe level by inhibiting cellular processes. The medical device industry concentrates on sterilization techniques. The food processing industry is primarily concerned with disinfection techniques. Laboratory studies indicate that 90% inactivation of most viruses and bacteria are possible by current UV germicidal lamps. Consequently, they are restricted to disinfection and not sterilization. However, surviving microorganisms are left in a weakened state, interfering with replication and increasing their susceptibility to other inactivation methods, including heat and chemical agents.

Traditionally used UV light at 2,537A inactivates microorganisms by direct contact. Thus, microorganisms to be reduced would have to be directly exposed to the UV source. This could be termed "static sterilization and disinfection." Microorganisms may be shielded from direct UV by organic or inorganic matter. This protection from UV light is referred to as "screening and/or shadowing effect". Screened microorganisms are not directly contacted by UV light. Therefore, screened microorganisms remain active following traditional UV irradiation.

Sterilization using UV light is very limited and unreliable. However, the potential to sterilize does

exist, as demonstrated by extensive research on airborne microbes. Additional reports support this claim, providing there is an unobstructed path of UV light to the target. For UV light to be considered a practical sterilization method, "shadow zones" and "screening effects" must be eliminated.

Reviewing traditional UV or "static sterilization and disinfection", three important aspects of UV processing follows:

1. 90% activation of most microorganisms,
2. "screening and/or shadowing" effects the process, and
3. surviving microorganisms are left in a weakened state, interfering with replication and increasing their susceptibility to other inactivation methods, including heat and chemical agents.

The dilemma of traditional UV light "static sterilization and disinfection" was overcome with the advent of a modified germicidal arc lamp. This improvement has generated the term "dynamic sterilization and disinfection." Traditional UV sources lack the capacity to penetrate and cause molecular excitation by photon energy. "Dynamic sterilization and disinfection" provides the capability of penetrating and causing molecular excitation. The excitation phenomenon involves the movement of organic and/or inorganic molecules, and the release of thermal energy.

In addition, Riboflavin (Vitamin B_2) occupies all cells including harmful microorganisms. Riboflavin will absorb UV light at 2200-2250A, 2660A, 3710A, 4440A, and 4750A. Absorption of ultraviolet at these wave lengths breaks apart the Riboflavin radical, destroying certain elements and leaving "free" radicals which cannot replicate. Dynamic sterilization and disinfection operates at the aforementioned wave lengths and thereby destroy the cell by disassembling the Riboflavin radicals.

The dynamic sterilization and disinfection (DSD-UV) lamps operate in the broadband UV spectrum (1000A to 4000+A). These DSD-UV lamps output high energy throughout the UV spectrum range. In addition, during operation the temperature at the center of the DSD-UV lamp is in excess of 500C. Utilizing the DSD-UV lamp, this unique synergism of traditional UV, high energy, broad band UV and heat transfer operate simultaneous on microorganisms. The total processing mechanism for dynamic sterilization and disinfection according to the present invention synergistic inactivation and disinfection.

Successful animal and human clinical studies involving implanted devices have demonstrated no adverse reactions following synergistic inactivation and disinfection processing and complete compatibility with living cells. Synergistic inactivation and disinfection has been examined with respect to the food processing industry. The process of the invention was found complimentary to both liquids and solids in microorganism reduction without altering product chemistry or physical composition.

The charts and graphs of Figs. 9-13 show test results obtained using the method and apparatus of the present invention.

While embodiments of the present invention have been described in detail, that has been done for the purpose of illustration, not limitation.